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APPLICATION NUMBER: 60/139,757

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Under 35 USC 111(b)

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PROVISIONAL APPLICATION
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Sir:

Herewith is a PROVISIONAL APPLICATION
Title: PROCESS FOR MAKING ... COMPONENTS

(Our Deposit Account No. 03-3975)

Our Order No. 71198 C# 259052 M#

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Date: 6/15/99

1. Specification: 24 pages 2. ☐ Specification in non-English language 3. ☒ Drawings: 5 sheet(s)

4. The invention ☐ was ☒ was not made by, or under a contract with, an agency of the U.S. Government.

If yes, Government agency/contact # =

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☒ Attached: Claims 1-21.

8. This application is made by the following named inventor(s) (Double check instructions for accuracy.):

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9. NOTE: FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet (PAT102A) with same information regarding additional inventors.

| | Large/Small Entity | | Fee Code |
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| 10. Filing Fee | \$150/\$75 | +150 | 114/214 |
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APPLICATION UNDER UNITED STATES PATENT LAWS

Invention: PROCESS OF MAKING DECORATIVE AUTOMOTIVE INTERIOR TRIM
ARTICLES WITH INTEGRATED COMPONENTS

Inventor(s): Ian S. WILLIAMS; Thomas R. STAUFFER; John A. GARDNER (Jr.);
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This is a:

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SPECIFICATION

PROCESS OF MAKING DECORATIVE AUTOMOTIVE INTERIOR TRIM ARTICLES WITH INTEGRATED COMPONENTS

BACKGROUND OF THE INVENTION

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1. Field of the Invention

This invention relates to a process of making automotive interior trim articles containing a panel structure mountable in an automobile vehicle, and in particular to
10 automobile interior trim articles, such as instrument panels and door panels, which include integrated ornamental components, especially molded ornamental components.

2. Description of the Related Art

15 Interior panels such as door panels and instrument panels generally include bodies formed from a decorative plastic covering that is supported on a rigid support structure and has mounted thereon a variety of ornamental components. Among components commonly found in vehicles are speaker grilles, cloth or other molded bolsters, map pockets, weather seals, wood-grain trim, and the like.

20 Production of interior panels conventionally involves the formation of the decorative plastic covering on the rigid support structure, followed by the post-application of the ornamental components. The post-application of ornamental components is by its very nature characterized by several drawbacks. For example, the post-application step requires the precise placement and fastening of the
25 components onto the interior panel covering. Moreover, to permit fastening of the components to the interior panel covering, the components usually require a backing component. These tasks can be very time-consuming and labor intensive, and often results in the presence of unwanted gaps between the components and interior panel covering. Additionally, the presence of an additional processing step increases
30 tooling and capital costs and labor requirements.

Thus, there is a significant need in the art for a process for producing interior panels in which the requirement for mechanical fasteners is significantly lessened or eliminated, and in which the labor and capital expenditure costs are reduced without compromising the quality of the interior panel product. The process should desirably

permit the precise positioning of the ornamental components without difficulty, and obviate the problems associated with the presence of gaps between the ornamental components and interior panel covering by decreasing the size of the gaps or eliminating the gaps altogether.

5

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to solve the aforementioned problems associated with the related art as well as to address the need expressed above. In accordance with the principles of this invention, this and other objects are attained by providing a process for making a panel structure which is mountable to an automobile vehicle and comprises a layered composite structure, a reinforcing substrate, and one or more ornamental components integrated with the layered composite structure.

In accordance with one embodiment of this inventive process, the layered composite structure is formed by a series of steps which include placing one or more ornamental components onto a mold surface, then establishing on exposed portions of the mold surface and components a thin outer layer with an exterior surface having an opaque visual appearance. Next, an inner layer is formed over the inner surface of the outer layer while the outer layer is on the mold surface to adhere the outer layer thereto and create the layered composite structure. Finally, the layered composite structure is united with the reinforcing substrate so that the reinforcing substrate reinforces the layered composite structure and the ornamental component or components integrated with the layered composite structure. Optionally, a soft cellular foam layer can be interposed between the inner layer and the reinforcing substrate.

Since the layered composite structures produced in accordance with this invention have an outer layer that can be formed by uniformly spraying of a precursor composition onto a heated mold surface and rear surfaces of ornamental components, the ornamental components are integrated into the layered composite structure without requiring a separate post-production step to attach the ornamental components with the skin. The adhesive strength of the outer layer integrates the ornamental components, thereby significantly reducing or eliminating the need for mechanical fasteners to mount the ornamental components. Moreover, because the post-

application step is eliminated or simplified, labor and tooling costs are advantageously reduced.

5 The layered composite structure made in accordance with this invention also exhibits excellent chemical, scuff and mar resistance to external influences. Further, appropriate additives can be introduced into one or more of the layers of the layered composite structure to provide the composite structure with the non-reflective and low gloss surface appearance desired for such panel structures. Furthermore, both the inner and outer layers of the layered composite structure are characterized by excellent extensibility, such that the layered composite structure can withstand
10 indentation and flexure during use without resulting in fracture of the outer layer over a wide temperature range, such as from -30°C to 120°C.

Another object of this invention is the provision of an automotive interior trim article containing a panel structure, and in particular the provision of a panel structure having an exterior surface which simulates the appearance and feel of authentic
15 leather, yet is integrated with one or more ornamental components.

In accordance with yet another embodiment of this invention, one or more ornamental components are placed onto a mold surface, after which a light-stable skin layer is formed over the backs of the ornamental components and the exposed portions of the mold surface, so that the ornamental components are adhered to the
20 skin layer. Finally, the skin with integrated components is united with the reinforcing substrate so that the reinforcing substrate reinforces the skin and the ornamental component or components integrated therewith. Optionally, a soft cellular foam layer can be interposed between the inner layer and the reinforcing substrate. The skin can then be post painted, if necessary.

25 The principles of this invention enunciated above are applicable to all types of interior panel structures with which components can be integrated, but have particular applicability to instrument panels (also referred to as dashboards), door panels, and rear interior quarter panels. Moreover, the principles of this invention are applicable to various types of vehicles, including passenger cars, trucks, vans, utility vehicles,
30 and others.

These and other objects, features, and advantages of this invention will become apparent from the following detailed description when taken in conjunction

with the accompanying drawings which illustrate, by way of example, the principles of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

5 The accompanying drawings illustrate an embodiment of the invention. In such drawings:

FIG. 1 is a sectional view of a door panel constructed in accordance with an embodiment of this invention;

10 FIG. 2 is a sectional view of a mold surface showing steps of applying ornamental components and, thereafter, a water-dispersed polyurethane composition to a heated mold surface to form a partially crosslinked light-stable polyurethane outer layer;

FIG. 3 is a sectional view similar to FIG. 2 showing a layered composite structure formed on the heated mold surface;

15 FIG. 4 is a sectional view showing a step of depositing a precursor for a relatively rigid polyurethane cellular foam intermediate layer on the inner layer while the layered composite structure is disposed on a mold surface; and

20 FIG. 5 is a sectional view showing a step of uniting the layered composite structure with integrated components on a mold surface with a pre-formed relatively rigid substrate disposed on another mold surface.

DETAILED DESCRIPTION OF THE INVENTION

Referring now more particularly to the drawings, there is shown in FIG. 1 a panel structure comprising a door panel, generally designated by reference numeral 25 10, made by a method in accordance with an embodiment of this invention. The panel structure 10 has an exterior surface 10a exposed to the vehicle interior and an interior surface 10b which is hidden from the vehicle interior when the panel-like structure 10 is mounted in the automobile vehicle. The panel-like structure 10 includes a rigid (or reinforcing) substrate 22 having one surface defining the interior surface 10b of the panel-like structure 10.

30 The panel-like structure 10 further includes a layered composite structure, generally designated by reference numeral 24, comprised of an outer layer 26 having an outer surface 26a (FIG. 2) defining at least a portion of the exposed exterior

surface 10a of the panel-like structure 10, and an inner layer 28. At least a portion of the outer layer 26 is exposed to the vehicle interior, while a portion of the outer layer 26 may be hidden from view by a decorative or ornamental component, such as component 15 and rug section 20. Finally, an intermediate layer 30 comprising a
5 relatively rigid (or semi-rigid) polyurethane cellular foam filler is interposed between the inner layer 28 and the rigid substrate 22.

As further illustrated in the drawings, and in particular FIG. 3, the inner layer 28, which is relatively thick in comparison to the outer layer 26, has an outer surface 28a adjacent to a portion of an inner surface 26b of the outer layer 26 and interfacially
10 chemically bonded with the outer layer 26.

As shown in FIG. 2, the method of this first embodiment utilizes a first mold component or part 32 having a first mold surface 34. The first mold component 32 preferably is formulated by electrolytically depositing nickel over a rigid cast epoxy substrate which is secondarily removed at the end of the deposition/plating process to
15 yield a self-supporting mold capable of being mounted and controlled in a tooling module. The first mold surface 34 has a complementary configuration to the desired configuration of the exterior surface 10a, and is grained to define a texture that substantially complements the desired texture of the exposed portion of the outer layer 26 and simulates real leather.

FIG. 2 illustrates the first steps in this embodiment. Ornamental components 15 and 20 are placed on the mold surface in predetermined locations, preferably subsequent to the application of a mold-releasing agent. As referred to herein, ornamental components means decorative and functional items, devices, and trim, including, by way of example, speaker grilles, cloth or molded bolsters, map pockets,
20 weather seals, wood-grain trim, and the like. The ornamental components can be held in place by the contour of the mold surface 34, a vacuum apparatus, and/or mechanical fasteners. Depending on the ornamental component selected, it may be advantageous to mask the component to prevent bleed-through of the outer layer 26 precursor composition (36). For example, such masking technique would be desirable
25 for speaker grilles.

The outer layer 26 is obtained by applying, preferably by spraying, a water-dispersed composition 36 onto the first mold surface 34 and components 15 and 20. In a preferred embodiment, the water-dispersed composition 36 comprises at least one
30

light-stable thermoplastic polyurethane containing one or more pendent hydroxyl and/or carboxyl functional groups, at least one desired coloring agent, and at least one heat-activated crosslinker. Suitable crosslinkers include blocked, heat-activated diisocyanates, carbodiimide ($\text{H}-\text{N}=\text{C}=\text{N}-\text{H}$), also known as cyanamide, and
5 compounds having a plurality of aziridine groups.

Application of the water-dispersed composition 36 onto exposed portions of the heated first mold surface 34 and the components 15 and 20 (which are heated via transfer conduction from the mold surface 34) induces chemical reaction between the pendent hydroxyl and/or carboxyl functional groups of the light-stable thermoplastic polyurethane and the heat-activated crosslinker to thereby produce a partially
10 crosslinked light-stable polyurethane. The first mold surface 34 should be heated to a sufficient temperature to drive the crosslinking reaction, but should not be so high as to cause delamination of the composition 36 from the mold surface 34. Preferably, the first mold surface 34 is heated to a temperature in a range of from about 60°C
15 (140°F) to about 82.2°C (180°F). The heating of the first mold surface 34 to such elevated temperatures prior to application of the water-dispersed composition 36 thereto also serves to melt and disperse semi-permanent mold releasing agents, such as microcrystalline wax mold releasing agents, applied to the first mold surface 34. The heated mold surface 34 thereby evaporates the wax dispersants and leaves a thin
20 residue that does not collect in the intricate grain detail of the first mold surface 34.

The water-dispersed composition 36 can be prepared by withdrawing the light-stable thermoplastic polyurethane and the heat-activated crosslinker from separate storage chambers in continuous, metered streams, and mixing these constituents immediately prior to contact with the first mold surface 34. Alternatively, the light-stable thermoplastic polyurethane and the crosslinker constituents can be stably
25 premixed, or "hot-potted", for up to about 24 hours at room temperature before application. This technique is known as "hot-potting" since the thermoplastic polyurethane and crosslinker slowly react with each other at room temperature in a spray pressure pot. If the admixture is hot-potted for more than about 24 hours at
30 room temperature before application of the water-dispersed composition 36 onto the first mold surface 34, the resulting crosslinked light-stable polyurethane exhibits inferior solvent and wear resistance properties and extensibility and may not provide an idealized bond to the inner layer 28. The water-dispersed composition 36 may be

formed from a colloid solution of resin particles, which is added to water to disperse the resin particles in the water.

Once the crosslinked light-stable polyurethane has been formed on the first mold surface 34, the water-dispersed composition 36 is substantially dried while being retained on the first mold surface 34 to obtain the outer layer 26 integrated with components 15 and 20. The crosslinked light-stable polyurethane can be subjected to a heat source to induce evaporation of the water and solvent therefrom and coalesce the resin particles to form the outer layer 26 with the outer surface 26a adjacent to the first mold surface 34. Such heat source is preferably integrated with the first mold 32, and preferably heats the first mold surface 34 to an elevated temperature of about 65.6°C (150°F) or higher. At least a portion of the outer surface 26a of the outer layer 26 has the desired touch, color, and grain-like configuration of the panel-like structure 10.

The spraying of the water-dispersed composition 36 onto and the formation of the outer layer 26 (by heating) on the components 15 and 20 integrates the components with the outer layer 26 via the adhesive properties of the composition 36. As a result, post-processing applications of the components 15 and 20 to the layered composite structure 24 are circumvented, thereby improving the overall efficiency of the process and reducing the labor and capital investment required to make the article 10. As referred to herein, integrated means that the ornamental components can be supported by the layered composite structure 24 by the adhesive properties of the outer layer 26 and inner layer 28 independent of mechanical fasteners. However, the existence of the integrated connection between the outer layer 26 and ornamental components does not foreclose or preclude the use of dielocks, mechanical fasteners or the like as supplemental fastening means.

Generally, the outer layer 26 has a thickness in a range of from about 0.002 cm to about 0.0038 cm (that is, from about 0.8 mils to about 1.5 mils ; or from about 0.0008 inch to about 0.0015 inch). The particular coloring agent selected can directly influence the desired thickness of the outer layer 26. Darker colors, such as grays and browns, usually only require a relatively small film thickness to mask the color of the inner layer 28, whereas lighter colors such as reds and blues usually dictate the provision of a relatively larger thickness to obtain an opaque, non-transparent outer layer 26 that conceals the inner layer 28 from view.

Next, the polyurethane elastomer inner layer 28, as is depicted in FIG. 3, is formed by spraying a rapidly reacting composition 42 onto the inner surface 26b of the outer layer 26 while the outer layer 26 is retained on the first mold surface 34 in a substantially dry state.

5 The inner layer 28 can be made from one or more base polymers that can be sprayed, cast, or otherwise applied by conventional techniques. Suitable base polymers include, for example and without limitation, PVC, thermoplastic polyurethanes, thermoplastic polyolefins, thermoplastic elastomers, and any combination thereof. The composition 42 for forming the inner layer 28 can also
10 contain one or more additives. Preferably, at least one of the base polymers and/or the additives is highly reactive with unreacted, residual functional groups of the crosslinker in the outer layer 26 that have not reacted with the pendent functional groups of the polyurethane of the outer layer 26. Unreacted functional groups of the crosslinker penetrate into the inner layer 28 and provide reactive sites for crosslinking
15 the polyurethane of the outer layer 26 with the inner layer 28. An interfacial chemical bond between the inner surface 26b of the outer layer 26 and the adjacent outer surface 28a of the inner layer 28 can thereby be formed. The layered composite structure 24 is thus obtained. If the crosslinking is performed under optimum crosslinking conditions, the boundary between the outer and inner layers 26 and 28 of
20 the layered composite structure 24 can become visually indistinct, such that a transition phase appears at the interface of the two layers. As referred to herein, interfacial chemical bonding encompasses, but is not limited to, such crosslinking reactions in which the interfacial boundary between the outer and inner layers 26 and 28 is visually indistinct and inseparable.

25 In a preferred embodiment, the inner layer 28 is prepared from a polyurethane elastomer, and even more preferably from an aromatic polyurethane elastomer. The polyurethane elastomer inner layer 28 may be formed by spraying a rapidly reacting composition 42 onto the inner surface 26b of the outer layer 26 while the outer layer 26 and components 15 and 20 are retained on the first mold surface 34 in a
30 substantially dry state. The rapidly reacting composition 42 preferably contains, at least one aromatic polyisocyanate and at least one polyol, which react with each other to form the non-light-stable polyurethane elastomeric inner layer 28. As referred to herein, the term elastomer encompasses a resilient polymer composition stretchable

under moderate tension and compressible and having a relatively high tensile strength and memory so that, upon release of the tension, the elastomer retracts into and recovers its original dimensions or dimensions substantially similar to its original dimensions.

5 In addition to being reactive with the polyisocyanate constituent, the polyol constituent of the rapidly reacting composition 42 can contain one or more pendent hydroxyl and/or carboxyl functional groups that are highly reactive with unreacted functional groups of the crosslinker of layer 26, which is preferably a blocked, heat-activated diisocyanate, in the outer layer 26 that have not reacted with the pendent
10 functional groups of the polyurethane of the outer layer 26. Unreacted functional groups of the blocked, heat-activated diisocyanate penetrate into the inner layer 28 and react with the pendent functional groups of the polyol constituent. As a result, the blocked, heat-activated diisocyanate crosslinks the polyurethane of the outer layer 26 with the polyurethane elastomer of the inner layer 28 and thereby forms an interfacial
15 chemical bond between the inner surface 26b of the outer layer 26 and the adjacent outer surface 28a of the inner layer 28. The layered composite structure 24 is thus obtained.

Generally, provisions should be taken to ensure that an adequate interfacial chemical bond is achieved between the inner surface 26b of the outer layer 26 and the
20 adjacent outer surface 28a of the inner layer 28. For example, once the blocked, heat-activated diisocyanate is activated by heat, the crosslinking reaction between the heat-activated light-stable diisocyanate and the pendent hydroxyl and/or carboxyl reactive groups of the thermoplastic polyurethane goes to completion within minutes, leaving the heat-activated light-stable diisocyanate with substantially no residual reactive sites
25 for crosslinking the polyurethane of the outer layer 26 with the polyol constituent of the rapidly reacting composition 42. Therefore, the rapidly reacting composition 42 generally should be applied within six minutes, and preferably within two to four minutes, of completing the application of the water-dispersed composition 36 to the first mold surface 34. Significant delays in applying the rapidly reacting composition
30 42 also can cause the outer layer 26 to constrict and delaminate from the first mold surface 34. As a consequence of delamination, the outer layer 26 will not have a shape complementary to the configuration of the first mold surface 34, and the entire composite 24 will have to be disposed of as scrap.

On the other hand, if the thermoplastic polyurethane of the water-dispersed composition 36 is not given sufficient time to crosslink before the rapidly reacting composition 42 is applied thereon, the polyol component of the rapidly reacting composition 42 can undergo a condensation reaction with unreacted hydroxyl and/or carboxyl pendent functional groups of the polyurethane of the outer layer 26 to form ester or ether linkages, respectively. While some formation of these linkages can advantageously enhance the interfacial chemical bond, the condensation reactions release water, which in excess amounts can act as a blowing agent and undesirably increase the cellularity of the inner layer 28 and interfere with the interfacial chemical bond.

The interfacial chemical bond is further enhanced by separately storing the highly reactive polyol and aromatic polyisocyanate constituent components of the rapidly reacting composition 42 in separate storage chambers and spraying these components on the inner surface 26b of the outer layer 26 so as to avoid contact between these components until spraying is conducted. A suitable dual nozzle spraying mechanism for accomplishing this task is disclosed in U.S. Patent Nos. 5,028,006 and 5,071,683. By keeping these components separate until immediately prior to spraying, a portion of the polyol reacts with the heat-activated diisocyanate (and the hydroxyl and/or carboxyl pendent functional groups of the thermoplastic polyurethane) before all of the polyol can completely react with the polyisocyanate.

Furthermore, given the hygroscopic nature of the aromatic polyisocyanate constituent of the rapidly reacting composition 42, it is important that the outer layer 26 and the surrounding atmosphere (e.g., humidity levels) be substantially dry during this spraying step in order to obtain a strong interfacial chemical bond. While small amounts of moisture may be retained in the outer layer 26, the concentration of such moisture should not be so great as to permit the water to substantially interfere with the reaction between the polyol and polyisocyanate constituents of the rapidly reacting composition 42. Undesirable reactions between the water and the polyisocyanate can disrupt the stoichiometric balance between the polyol and the polyisocyanate, leaving localized unreacted polyol deposits behind on the layered composite structure 24. The water also can serve as a blowing agent, reacting with the polyisocyanate to release carbon dioxide which imparts a cellular structure to the inner layer 28. Excess amounts of water also can deleteriously interfere with the

crosslinking reaction effected via the polyol and the residual reactive sites of the blocked, heat-activated diisocyanate.

The rapidly reacting composition 42 is preferably applied to the inner surface 26a of the outer layer 26 at an elevated temperature to advance these objectives.

- 5 Suitable temperatures to which the first mold component 34 can be heated range, by way of example and without limitation, from about 60°C (140°F) to about 71.1°C (160°F).

- 10 As mentioned above, the inner layer 28 can also be formed by casting, for example, a PVC or thermoplastic polyurethane casting composition. Suitable techniques and apparatuses for accomplishing casting are disclosed in the collection of USSN 09/093,613, U.S. Patent No. 4,623,503, U.S. Patent No. 4,621,995, U.S. Patent No. 5,597,586, and U.S. Patent No. 4,217,325, the complete disclosures of which are incorporated herein by reference.

- 15 Generally, the inner layer 28 can have a thickness in a range of from about 0.10 cm to about 0.15 cm (that is, from about 40 mils to about 60 mils; or from about 0.040 inch to about 0.060 inch).

- 20 The layered composite structure 24 with integrated components 15 and 20 is then demolded (i.e., removed) from the first mold surface 34. The demolding process is often a relatively labor intensive, tedious, and time consuming task. Formation of tears in or undue stretching of the layered composite structure 24 during demolding can irreversibly ruin and thereby necessitate disposal of the layered composite structure 24 as scrap. Such demolding problems and inefficiencies are largely overcome by practice of this invention, since the interfacial chemical bond between the outer layer 26 and inner layer 28 strengthens the layered composite structure 24 by discouraging separation of the outer and inner layer 26 and 28 during demolding procedures. Moreover, such demolding problems and inefficiencies are further obviated by the use of the aromatic-based elastomer as the inner layer 28, since the aromatic-based elastomer has advantageous physical properties over non-aromatic elastomers.

- 30 To enhance the releasability from the first mold surface 34 further, the mold surface 34 can be pretreated with a releasing agent prior to the application of the water-dispersed composition 36 and, optionally, prior to the application of the ornamental components 15 and 20. Exemplary releasing agents include, without

limitation, high molecular weight microcrystalline wax mold releases, such as Chem-Trend PRC 7140, supplied by Chem-Trend, Inc. of Howell, Michigan, or PRC 2006, also supplied by Chem-Trend. These mold releasing agents dry quickly on a heated mold within about 5 to about 10 seconds and form a release barrier between the
5 grained mold surface 34 and the outer layer 26. Care should be taken to avoid the accumulation of the mold releasing agent on the first mold surface 34 or excess solids content in the agent, since such accumulation or excess solids content tends to fill the interstices of the decorative, grained mold surface 34, thereby removing from the exterior surface of the panel structure 10 the appearance of the intricate, hair-like
10 grained configuration of the mold surface 34. Further, the use of excess mold releasing agents can cause the agents to transfer from the first mold surface 34 to the layered composite structure 24 during demolding of the composite structure 24, thus requiring additional wash-removal and drying steps after demolding and hence a loss in productivity.

15 After being demolded from the first mold surface 34, the layered composite structure 24, including the combination of the outer and inner layers 26 and 28 with the components 15 and 20, can be examined for defects with a light source (not shown) while the layered composite structure 24 is positioned on a transparent substrate (not shown). Such defects usually are present as cosmetic blemishes in the
20 outer layer 26, and may include the presence of tears and rupturable portions lacking sufficient thicknesses to withstand stresses associated with demolding or the further processing steps, especially the uniting step. If minor and isolated, such localized defects can be remedied by post application of additional water-dispersed composition 36 onto the outer layer 26. Additionally, minor tears or thin areas can be repaired
25 using thermoplastic, heat formable polyurethane tape on the backside 28b of the layered composite structure 24. Advantageously, the need to scrap the entire layered composite structure 24 is thereby averted. As a cautionary note, however, post application spray repair of surface 26a is generally undesirable and its use should be minimized to correcting localized defects, since post application spray repair can
30 negate the grained leather-like appearance of the outer surface 26a of the outer layer 26 which is transcribed from the first mold surface 36.

As discussed in further detail below, the steps of demolding and examining of the layered composite structure 24 from the first mold surface 36 are not required to

be conducted immediately subsequent to the formation of the layered composite structure 24. For example, the layered composite structure 24 optionally can be maintained against the first mold surface 34 until completion of the panel-like structure 10.

5 After the layered composite structure 24 is demolded from the first mold surface 34 and examined, the layered composite structure 24 is placed on a second mold surface 52 of a second mold part 50. As shown in FIG. 4, the second mold surface 52 is shaped to have a complementary configuration to the exterior surface 10a. Then, a reactive mixture 44 for forming a semi-rigid cellular foam, such as a
10 polyurethane semi-rigid cellular foam, is applied to an inner surface 28b of the inner layer 28 while the composite structure 24 is disposed on the second mold surface 52 to form the intermediate layer 30. The reactive mixture 44 can be applied, for instance, by employing high pressure impingement mixing and a mix-head nozzle. The second mold component 50 is generally heated to a temperature in a range of
15 from about 35°C to about 45°C, and more preferably in a range of from about 35°C to about 40°C, during application of the reactive mixture 44. The mixture 44, which is typically relatively viscous, is in a transient state of reaction during application to the second mold component 50 and begins to foam within seconds of application.

20 Although the desired thickness of the intermediate layer is partially dependent upon the intended use of the panel structure 10, generally the intermediate layer can have a thickness in a range of from about 5 mm to about 12 mm.

25 Once the reactive mixture 44 has been applied to the layered composite structure 24 located on the second mold surface 52, a third cooperating mold part or component 60 carrying the pre-formed rigid substrate 22 is moved into cooperating relation with the second mold component 50, as shown in FIG. 5. The third mold component 60 has a third mold surface (unnumbered) with a complementary configuration to the interior surface 10b of the panel-like structure 10. Thereafter, the reactive mixture 44 is foamed and cured, preferably under heat of approximately 43.3°C (110°F) and a self-generated cavity pressure of about 0.8 atm to form the
30 intermediate layer 30. The semi-rigid polyurethane cellular foam serves to unite the layered composite structure 24 with the pre-formed rigid substrate 22 disposed on the third mold surface 60. The panel-like structure including the combination of the layered composite structure 24, the rigid substrate 22, and the intermediate layer 30

then can be removed from the mold parts 50 and 60 with components 15 and 20 integrated thereon.

In its broadest aspects, several variations and modifications to the above-discussed article can be implemented without departing from the scope of this invention. For example, a non-foamable adhesive can be selected for uniting the layered composite structure 24 to the rigid substrate 22.

In accordance with another variant embodiment, multi-water-dispersed compositions containing different coloring agents can be respectively applied to different portions of the panel structure to produce discretely masked colors. Where the selected color or colors are to be changed, in practice it has been found that minimal downtime (on the order of about 0.5 hours) is required.

In accordance with still another variant embodiment, the outer layer 26 can exhibit a dualtone or multitone appearance. This variant embodiment can be accomplished, for example, by abrasive treatment of a portion of the mold surface of the tooling. The greater the amount of abrasive treatment, the duller the appearance of the outer layer 26. A dualtone appearance can be especially desirable for instrument panels, since the upper region of an instrument panel generally should have a low gloss in order to reduce reflectance and veiling glare.

Several variations and modifications to the above-discussed method also can be practiced without departing from the scope of this invention. For example, as mentioned above, the layered composite structure 24 can be retained in the first mold component 32 instead of being demolded and transferred to a second mold component 50 for the uniting step. In accordance with another variant embodiment of this invention, the layered composite structure 24 can be returned to the first mold component 32 after being examined and treated.

In accordance with another variant of this invention, a secondary or alternative heat source can be applied for activating the reaction between the light-stable thermoplastic polyurethane and the crosslinker. For example, the water-dispersed composition 36 can be preheated before being applied to the first mold surface 34, such that the first mold surface 34 does not have to be heated to initiate the reaction between the crosslinker and the light-stable thermoplastic polyurethane.

The illustrated embodiment of this invention can also be modified by applying the reactive mixture 44 for forming the polyurethane semi-rigid cellular foam 30 to

the surface of the rigid substrate 22 instead of the layered composite structure 24.

Alternatively, the second and third mold components 32 and 50 can be cooperatively engaged to define a cavity between the inner surface 28b of the inner layer 28 and the outer surface of the substrate 22, with the reactive mixture 44 thereafter being injected
5 between the rigid substrate 22 and the composite structure 24.

In order to further elucidate the decorative automotive interior trim article and method of this invention, the following discussion specifies suitable and preferred constituents and conditions for making the article of this invention and for carrying out the process of this invention.

10 In a preferred embodiment, the water-dispersed composition 36 used to prepare the outer layer 26 comprises at least one light-stable thermoplastic polyurethane, at least one desired coloring agent, and at least one crosslinker (preferably one or more blocked, heat-activated aliphatic diisocyanates). The light-stable thermoplastic polyurethane is preferably prepared from a high molecular
15 weight aliphatic thermoplastic polyurethane containing hydroxyl and/or carboxyl pendent functional groups which are chemically reactive with the crosslinker. The average molecular weight of the thermoplastic polyurethane can be in a range of from about 5000 to about 7000, and more preferably about 6000. An exemplary thermoplastic polyurethane and blocked, heat-activated diisocyanate crosslinker can
20 be obtained from Titan Finishes Corp. of Detroit, Michigan under the trade designation PROTOTHANE WR, WATER BASED IN-MOLD COATING. The diisocyanate may be cyclic or non-cyclic, but should be light stable. As referred to herein, diisocyanates also encompasses prepolymers having two -NCO groups which are reactive with the thermoplastic polyurethane. An exemplary aliphatic
25 diisocyanate is hexamethylene diisocyanate (HMDI), which is available from Bayer, Rhone Poulenc, and Nippon Polyurethane. An exemplary water-dispersed composition comprising a thermoplastic polyurethane and carbodiimide can be obtained from C.F. Jameson & Company, Inc. of Bradford, Mass. under the trade designation JAMESON WVF SERIES FLEXCOAT IMC. The desired weight ratio
30 of thermoplastic polyurethane to crosslinker for these particular compositions is about 8 to 1 by volume (equivalent ratio of 1.44 thermoplastic polyurethane to 1.08 crosslinker on a dry basis).

5 The water-dispersed composition 36 can be prepared by providing the thermoplastic polyurethane component as a colloidal solution in a solvent such as N-methyl pyrrolidone, then dispersing the solution by adding water, the coloring agent, and conventional additives, if desired. Sufficient water (e.g., about 61.1% by weight) can be added so that the solvent concentration in the water-dispersed composition 36 is, for example, about 8.1% by weight before drying.

10 The optional additives in the water-dispersed composition 36 can include, without limitation, any combination of the following: heat and ultra-violet light stabilizers, pH stabilizers to maintain an alkaline state of dispersion, plasticizers, antioxidants, dulling agents, surfactants, colloidal protectants to maintain particles in suspension, carbon black, thixotropic agents (e.g., hydroxy methyl cellulose), and fillers such as clay particles.

15 The water-dispersed composition 36 can contain, for example, about 25% to about 35% solids by weight, and more preferably about 29% solids by weight, about 10% to about 80% water by weight, and more preferably about 61% water by weight, and about 6% to 10% solvents by weight, depending on desired color and additives. An insufficient amount of water in the composition 36 can adversely affect the viscosity of the composition 36 and thus adversely affect the application of the water-dispersed composition 36 onto the first mold surface 34. On the other hand, an excess
20 amount of water in the water-dispersed composition 36 can alter the sprayability and coating efficiency of the water-dispersed composition 36.

25 To the thermoplastic polyurethane solution may be added a solution of the blocked, heat-activated diisocyanate, which can include as a solvent, for example, 1-methyl-2-pyrrolidone and/or 4-hydroxy-4-methyl-2-pentanone. A discussion of blocked isocyanates is included in Practical Chemistry of Polyurethanes and Diisocyanates, Akron Polymer Laboratories, David Russell (1991), the complete disclosure of which is incorporated herein by reference. The blocked, heat-activated aliphatic diisocyanate is preferably maintained at room temperature and protected
30 from heat until use. When influenced by the heat, such as the heat of the tooling during spraying application, the blocked, heat-activated aliphatic diisocyanate reacts with the hydroxyl and/or carboxyl groups of the thermoplastic polyurethane to crosslink the thermoplastic polyurethane with itself or with polyol constituents of the rapidly reacting composition.

Alternatively, the water-dispersed composition 36 can be prepared by adding to the thermoplastic polyurethane solution a solution comprising the carbodiimide, which can include, for example, glycol ether acetate and/or xylene as the solvent.

5 Aromatic Polyurethane Elastomer Inner Layer

Exemplary polyisocyanates that can be selected as part of the composition 42 for forming the inner layer 28 include diisocyanates having aromatic closed-ring structures, such as diphenylmethane diisocyanate prepolymer (MDI prepolymer), which can be obtained from BASF Corp. of Wyandotte, MI. under the trade designation ELASTOLIT M50555T, ISOCYANATE, NPU U05275, or diphenylmethane-4,4'-diisocyanate (MDI), or mixed isomers of MDI or mixtures of the above, which are available from BASF or Dow Chemical Corp. of Midland, MI, Mobay (Bayer) Chemical Corp. of Baytown, Texas, or ICI America of Geismar, LA. The above-mentioned non-light-stable aromatic polyisocyanates are very desirable for use in the inner layer in view of the higher rate of reactivity and completion of property development and better physical properties (e.g., tensile strength, elongation, and tear strength) of these non-light-stable aromatic polyisocyanate when compared to light-stable aliphatic-based isocyanates such as isophorone diisocyanates, in which the -NCO groups are sterically hindered due to their spatial arrangement at either end of the molecule. By contrast, the aromatic diisocyanates preferred for this invention have -NCO groups directly attached to the aromatic ring. In this preferred embodiment, the aromatic diisocyanates yield faster rates of reaction because of the arrangement and reactivity of the -NCO groups on the aromatic ring structure (e.g., in diphenylmethane diisocyanate) and the availability of the -NCO groups for reaction with the hydrogen donors of the -OH type residing on the organic chain of the polyols of the rapidly reacting composition 42.

Suitable polyols for this rapidly reacting composition 42 include, by way of example, polyether polyols having average molecular weights in a range of from about 200 to about 2000 and containing one or more pendent hydroxyl and/or carboxyl groups in addition to primary hydroxyl groups, which can chemically react with unreacted functional -NCO groups of the blocked, heat-activated diisocyanate and the hydroxyl and/or carboxyl pendent functional groups of the polyurethane of the

outer layer 26. An exemplary polyol is ELASTOLIT M50555R NPU U05274 from BASF Corp. of Wyandotte, MI.

The rapidly reacting composition 42 can also contain appropriate additives, including, by way of example and without limitation, any combination of the following: heat and ultra-violet light stabilizers, pH stabilizers, antioxidants, dulling agents, surfactants, carbon black, chain extenders (e.g., ethylene glycol), thixotropic agents (e.g., amorphous silica), fillers such as clay particles, and catalysts such as tin catalysts (e.g., dibutyltin dilaurate).

10 Non-Aromatic Polyurethane Elastomer Inner Layer

Exemplary polyisocyanates that can be selected for making the inner layer 28 include polyisocyanates having closed aliphatic ring structures with pendent -NCO groups, such as isophorone diisocyanate, which can be obtained from Recticel under the tradename ISOFAST. Also suitable is tetramethyl xylene diisocyanate, which can be obtained from Texaco under the tradename TMXDI.

Suitable polyols for this rapidly reacting composition include, without limitation, polyether polyols having molecular weights in a range of from about 220 to about 250 and containing one or more pendent hydroxyl and/or carboxyl groups (in addition to primary hydroxyl groups), which can chemically react with unreacted functional -NH groups of the carbodiimide and the hydroxyl and/or carboxyl pendent functional groups of the polyurethane of the outer layer 26. An exemplary polyol is POLYFAST from Recticel.

Additives as mentioned above in connection with the aromatic polyurethane elastomer may be used for non-aromatic polyurethane elastomer inner layers 28 as well.

Cast PVC Inner Layer

Where PVC is selected as the base polymer, the casting composition can include one or more plasticizers. In a preferred embodiment, the plasticizers selected for this invention are capable of reacting with the crosslinker (e.g., carbodiimide) in the outer layer 26, so that the crosslinker can successfully crosslink the polyurethane of the outer layer 26 with the plasticizer of the casting composition. Exemplary plasticizers include, without limitation, plasticizers having one or more pendent

hydroxyl or carboxyl functional groups. These plasticizers are preferably incorporated around the backbone of the base polymer as an internal lubricant.

Preferably, both a low molecular weight plasticizer and a medium molecular weight plasticizer are included in the casting composition having PVC as its base polymer. The low molecular weight plasticizer is selected to provide low temperature flexibility, so that performance of the inner layer 28 at low temperatures, such as -30°C, is not hindered. An exemplary low molecular weight plasticizer is di-2-ethylhexylphthalate (also known as DUP). On the other hand, the medium molecular weight plasticizer is selected to provide high temperature stability to the inner layer 28. An exemplary medium molecular weight plasticizer is trioctyltrimellitate (TOTM).

The amount of low molecular weight plasticizer should be maintained fairly low so as to reduce volatilization and, consequently, window fogging. For example, the weight ratio of low molecular weight plasticizer to PVC base resin in the casting composition can be from about 0.25:100 to about 1:100. The weight ratio of medium molecular weight plasticizer to PVC base resin in the casting composition can be in a range of from about 10:100 to about 40:100, and more preferably in a range of from about 20:100 to about 40:100. If an insufficient amount of medium molecular weight plasticizer is used, the inner layer 28 may not exhibit adequate high temperature aging properties, resulting in, for example, premature stiffening of the inner layer 28 after exposure to elevated temperatures. On the other hand, if an excess amount of medium molecular weight plasticizer is used, the article surface may tend to gloss at elevated temperatures, creating unacceptable surface reflectance.

Where PVC is selected as the base polymer of the casting composition, the casting composition can be prepared by any suitable technique, including suspension or mass polymerization followed by drying to provide a white, free-flowing powder of PVC having, for example, an average particle size of about 350 µm. The resulting PVC powder can then be thoroughly mixed with the plasticizer to form the casting composition by employing any suitable technique, such as high energy compounding. During compounding, the plasticizer is absorbed by the PVC and thereby causes the PVC to swell. Compounding can be performed, for example, at a temperature in a range of from about 60°C (about 150°F) to about 88°C (about 190°F).

The plasticizer selected should impart thermal stability to the PVC powder and be permanent to render the article flexible for the life of the application. Generally, PVC powder consists of discrete particle groups that, when subjected to excessive temperatures, decompose prior to melting. This decomposition liberates hydrogen chloride, which autocatalytically degrades the PVC. Since the PVC is melted during gelling and fusing steps, a suitable internal plasticizer is mixed with and absorbed in the PVC powder prior to casting in order to inhibit thermal degradation of the PVC and provide the inner layer 28 with a soft, flexible, compressing feel.

Preferably, the plasticizer is bound in the PVC matrix with sufficient bond energy to form a permanent part of the polymer matrix and thereby permit the finished fused article to exhibit good flexibility and weathering at super- and sub-ambient conditions in use.

The casting composition having PVC as its base resin can contain appropriate additives, including, by way of example and without limitation, any combination of the following: heat and ultra-violet light stabilizers, such as hydroquinones; internal lubricants, such as stearic acid; antioxidants; dulling agents; carbon black; and fillers, such as clay and/or diatomaceous earth. Other additives can also be introduced into the inner layer 28 to protect against oxidation and destabilization of the cast PVC. Such additives include barium, calcium, and zinc-heat stabilizers, such as barium nonylphenate, calcium carboxylate, and zinc stearate. These and other additives can be included to form the dry resin material by using, by way of example and without limitation, a high intensity dry powder mixer such as a Henschel mixer.

In addition, the PVC composition can comprise one or more copolymer alloys or blends of PVC and another polymer, such as one or more polyurethanes. Such copolymer alloys and blends can be prepared by techniques well known to those skilled in the art, such as compounding.

Cast Thermoplastic Polyurethane Inner Layer

Where a thermoplastic polyurethane is selected as the base polymer for the casting composition, the thermoplastic polyurethane preferably contains at least one ethylenically unsaturated bond in its backbone and/or hydroxyl groups. In a preferred embodiment, the ethylenically unsaturated bond and/or hydroxyl groups of the thermoplastic polyurethane is/are capable of reacting with the crosslinker (e.g.,

carbodiimide) in the outer layer 26, so that the crosslinker can successfully crosslink the polyurethane of the outer layer 26 with the polyurethane of the casting composition. Exemplary thermoplastic polyurethanes include, without limitation, ESTANE (provided by B.F. Goodrich of Akron, Ohio) and PELLETHANE (provided by Dow Chemical Company of Midland Michigan).

The thermoplastic polyurethane of the casting composition can be prepared by, for example, a prepolymerization technique, followed by drying, compounding, chopping, and grinding, to provide a free-flowing powder of thermoplastic polyurethane. Excess polyols can be provided in preparing the thermoplastic polyurethane of casting composition. As mentioned above, the hydroxyl groups of the excess polyols can serve to promote crosslinking and the chemical bonding between the outer layer 26 and the inner layer 28. The resulting thermoplastic polyurethane powder typically has a brownish appearance, and can possess, for example, a 425 mesh size. The powder can contain additives, as needed or required by the intended use, to form the composition by employing any suitable technique, such as introducing the additives during prepolymerization. The weight ratio of the total additives to the base resin can be, for example, in a range of from about 3:100 to about 7:100, depending on the intended use and additives included.

The casting composition including a thermoplastic polyurethane as its base polymer can contain appropriate additives, including, by way of example and without limitation, any combination of the following: heat stabilizers; flexibilizers, such as low molecular weight polyurethanes (incorporated into the backbone, for example, during the compounding or like step); antioxidants; dulling agents; carbon black; fillers, such as clay particles; and free flowing additives. Other additives can also be introduced into the inner layer 28 to protect against scorching. These and other additives can be included to form the dry resin material by using, by way of example and without limitation, a high energy extruder/chopper

In similar fashion, other thermoplastic powders based upon polyolefins or elastomers may be formed. Extruded micropellets of the PVC, TPU, TPO, TPE, or other thermoplastic formulations or combinations thereof may be cast instead of the powder form.

Various blends of polyether polyols and polyisocyanates having suitable resilience properties can be employed to form the semi-rigid polyurethane cellular

foam of the intermediate layer 30. For example, the polyisocyanate blend can include methylene diisocyanate. The semi-rigid polyurethane cellular foam also can contain appropriate additives, including, by way of example and without limitation, any combination of the following: surfactants, antioxidants, fillers, stabilizers, catalysts such as tin catalysts (e.g., dibutyl tin dilaurate) and tertiary amines (e.g., diethanolamine), and small amounts of foaming agents such as water. In this regard, it is noted that the condensation reaction between the blends of polyols and polyisocyanates releases water, which reacts with the polyisocyanate to generate carbon dioxide and thereby impart the cellular structure to the intermediate layer 30. Accordingly, a slightly stoichiometric excess of polyol can be provided to form the semi-rigid polyurethane cellular foam.

The rigid substrate 22 may be formed from any material possessing the requisite strength to reinforce and mount the outer layer 26, inner layer 28, and intermediate layer 30. Suitable materials include any material with sufficient rigidity to permit the composite to be mounted into a vehicular sub-structure, including, by way of example, injection molded thermoplastics, such as, without limitation, a styrene maleic anhydride (SMA), acrylonitrile butadiene styrene (ABS), polycarbonates (PC), an alloy of ABS-PC, reinforced reaction injection molded polyurethanes (RRIM), metals, metal alloys, wood fiber composites, or any combination thereof.

The rigid substrate 22 may be formed from at least one polyolefin selected from the group consisting of polypropylene, ethylene-propylene copolymers, thermoplastic olefins (TPOs), and thermoplastic polyolefin elastomers (TPEs), with fillers, such as reinforcement nanoparticles, dispersed within the polyolefin. The reinforcement nanoparticles generally comprise less than 15% of the total volume of the rigid substrate 22. The nanoparticles derive their name from the small magnitude of their dimensions. The nanoparticles comprise one or more generally flat platelets, with each platelet having a thickness of between about 0.7 and about 1.2 nanometers. Generally, the platelets each have an average thickness of approximately 1 nm thick, with an aspect ratio (which is the largest dimension divided by the thickness) of about 50 to about 300.

The nanoparticles (including the platelets) are derivable from larger layered mineral particles. Any layered mineral capable of being intercalated may be

employed in this invention. Layered silicate minerals are preferred. The layered silicate minerals that may be employed include natural and artificial minerals. Non-limiting examples of more preferred minerals include montmorillonite, vermiculite, hectorite, saponite, hydrotalcites, kanemite, sodium octosilicate, magadite, and kenyaite. Mixed magnesium and aluminum hydroxides may also be used. Among the most preferred materials is montmorillonite. Various other clays can be used, such as claytone H.Y.

To exfoliate the larger mineral particles into their constituent layers, different methods may be employed. For example, swellable layered minerals, such as montmorillonite and saponite are known to intercalate water to expand the inter layer distance of the layered mineral, thereby facilitating exfoliation and dispersion of the layers uniformly in water. Dispersion of layers in water is aided by mixing with high shear. The mineral particles may also be exfoliated by a shearing process in which the mineral particles are impregnated with water, then frozen, and then dried. The freeze dried particles are then mixed into molten polymeric material and subjected to a high sheer mixing operation so as to peel individual platelets from multi-platelet particles and thereby reduce the particle sizes to the desired range.

The reinforcing substrate 22 may be prepared by combining the platelet mineral with the desired polymer in desired ratios. The components may be blended by general techniques known to those skilled in the art. For example, the components can be blended and then melted in mixers or extruders.

Additional specific preferred methods, for the purposes of this invention, for forming a polymer composite having dispersed therein exfoliated layered particles are disclosed in U.S. Patent Nos. 5,717,000, 5,747,560, 5,698,624, and WO 93/11190, each of which is hereby incorporated by reference. For additional background the following are also incorporated by reference: U.S. Patent Nos. 4,739,007 and 5,652,284.

Although the method of this invention has been embodied above in connection with the preparation of a door panel, it is understood that the method is equally applicable to other panel-like structures, including for example instrument panels and interior rear quarter panels, package trays, glove box covers, etc.

The complete disclosures of any United States or foreign patents or patent applications or provisional applications mentioned or cited hereinabove are hereby incorporated by reference into the present specification.

The foregoing detailed description of the preferred embodiments of the
5 invention has been provided for the purposes of illustration and description. It is not
intended to be exhaustive or to limit the invention to the precise embodiments
disclosed. Many modifications and variations will be apparent to practitioners skilled
in this art. The embodiments were chosen and described in order to best explain the
principles of the invention and its practical application, thereby enabling others skilled
10 in the art to understand the invention for various embodiments and with various
modifications as are suited to the particular use contemplated. It is intended that the
scope of the invention be defined by the following claims and their equivalents.

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WHAT IS CLAIMED IS:

1. A process for making a panel structure mountable in a vehicle to form a part of the interior thereof, the panel-like structure comprising a layered composite structure, a reinforcing substrate, and one or more ornamental components facing the interior of the vehicle, said process comprising:

placing the ornamental components on a mold surface, each of the ornamental components having an outer surface facing the mold surface and remaining surfaces not facing the mold surface;

- spraying a thin outer layer on the remaining surfaces of the ornamental components and on portions of the mold surface not covered by the ornamental components to adhere the outer layer with and integrate the outer layer to the ornamental components; and

- applying a resin formulation over the inner surface of the outer layer while the outer layer is on the mold surface to create an inner layer adhered to the outer layer, the inner and outer layers collectively forming the layered composite structure.

2. A process according to claim 1, further comprising uniting the layered composite structure after the formation thereof with the reinforcing substrate so that the reinforcing substrate reinforces the layered composite structure and the ornamental components integrated with the layered composite structure.

3. A process according to claim 1, wherein the outer layer has a thickness in a range of from about 0.002 cm to about 0.0038 cm .

4. A process according to claim 1, wherein the inner layer has a thickness in a range of from about 0.10 cm to about 0.15 cm.

5. A process according to claim 1, further comprising the step of precoating the mold surface with a microcrystalline wax mold releasing agent.

6. A process according to claim 1, wherein the mold surface is shaped to define a corresponding configuration of an exterior surface of a door panel.

7. A process according to claim 1, wherein the mold surface is shaped to define a corresponding configuration of an exterior surface of an instrument panel.

5 8. A process for making a panel structure mountable in a vehicle to form a part of the interior thereof, the panel-like structure comprising a layered composite structure, a reinforcing substrate, and one or more ornamental components facing the interior of the vehicle, said process comprising:

10 placing the ornamental components on a mold surface, each of the ornamental components having an outer surface facing the mold surface and remaining surfaces not facing the mold surface;

15 spraying a water-dispersed composition on the remaining surfaces of the ornamental components and on portions of the mold surface not covered by the ornamental components, the water-dispersed first composition comprising at least one light-stable thermoplastic polyurethane containing at least one pendent functional group selected from the group consisting of hydroxyl and carboxyl functional groups, at least one desired coloring agent, and at least one light-stable, heat-activated crosslinker;

20 applying sufficient heat to induce partial crosslinking of the light-stable thermoplastic polyurethane with the crosslinker;

substantially drying the water-dispersed composition while on the mold surface so as to establish the outer layer which has an exterior surface with an opaque visual appearance and is integrated to the ornamental components; and

25 applying a resin composition onto an inner surface of the outer layer while the outer layer is on the mold surface to create an inner layer adhered to the outer layer, the inner and outer layers collectively forming the layered composite structure.

30 9. A process according to claim 8, further comprising uniting the layered composite structure after the formation thereof with the reinforcing substrate so that the reinforcing substrate reinforces the layered composite structure and the ornamental components integrated with the layered composite structure.

10 A process according to claim 8, wherein the resin composition contains
at least one polyisocyanate and at least one polyol, and wherein the inner layer is
crosslinked with the polyurethane of the outer layer via residual unreacted functional
groups of the crosslinker to form interfacial chemical bonding between the inner
5 surface of the outer layer and an adjacent surface of the inner layer.

11. A process according to claim 10, wherein the polyisocyanate is
aromatic, and wherein the crosslinker is a blocked, heat-activated diisocyanate.

10 12. A process according to claim 11, wherein the aromatic polyisocyanate
is a diphenylmethane diisocyanate prepolymer or diphenylmethane-4,4'-diisocyanate.

13. A process according to claim 11, wherein the blocked, heat-activated
diisocyanate is hexamethylene diisocyanate.
15

14. A process according to claim 10, wherein the polyol contains one or
more pendent hydroxyl, carboxyl, or hydroxyl and carboxyl functional groups.

15. A process according to claim 8, wherein the outer layer has a thickness
20 in a range of from about 0.002 cm to about 0.0038 cm .

16. A process according to claim 8, wherein the inner layer has a thickness
in a range of from about 0.10 cm to about 0.15 cm.

25 17. A process according to claim 8, further comprising the step of
precoating the mold surface with a microcrystalline wax mold releasing agent.

18. A process according to claim 8, wherein the reinforcing substrate
contains nanoparticles.
30

19. A process according to claim 8, wherein the mold surface is shaped to
define a corresponding configuration of an exterior surface of a door panel.

20. A process according to claim 7, wherein the mold surface is shaped to define a corresponding configuration of an exterior surface of an instrument panel.

5 21. A process for making a panel structure mountable in a vehicle to form a part of the interior thereof, the panel-like structure comprising a skin, a reinforcing substrate, and one or more ornamental components facing the interior of the vehicle, said process comprising:

10 placing the ornamental components on a mold surface, each of the ornamental components having an outer surface facing the mold surface and remaining surfaces not facing the mold surface;

spraying a resin formulation over the inner surface of the outer layer while the outer layer is on the mold surface to create an inner layer adhered to the outer layer, the inner and outer layers collectively forming the layered composite structure.

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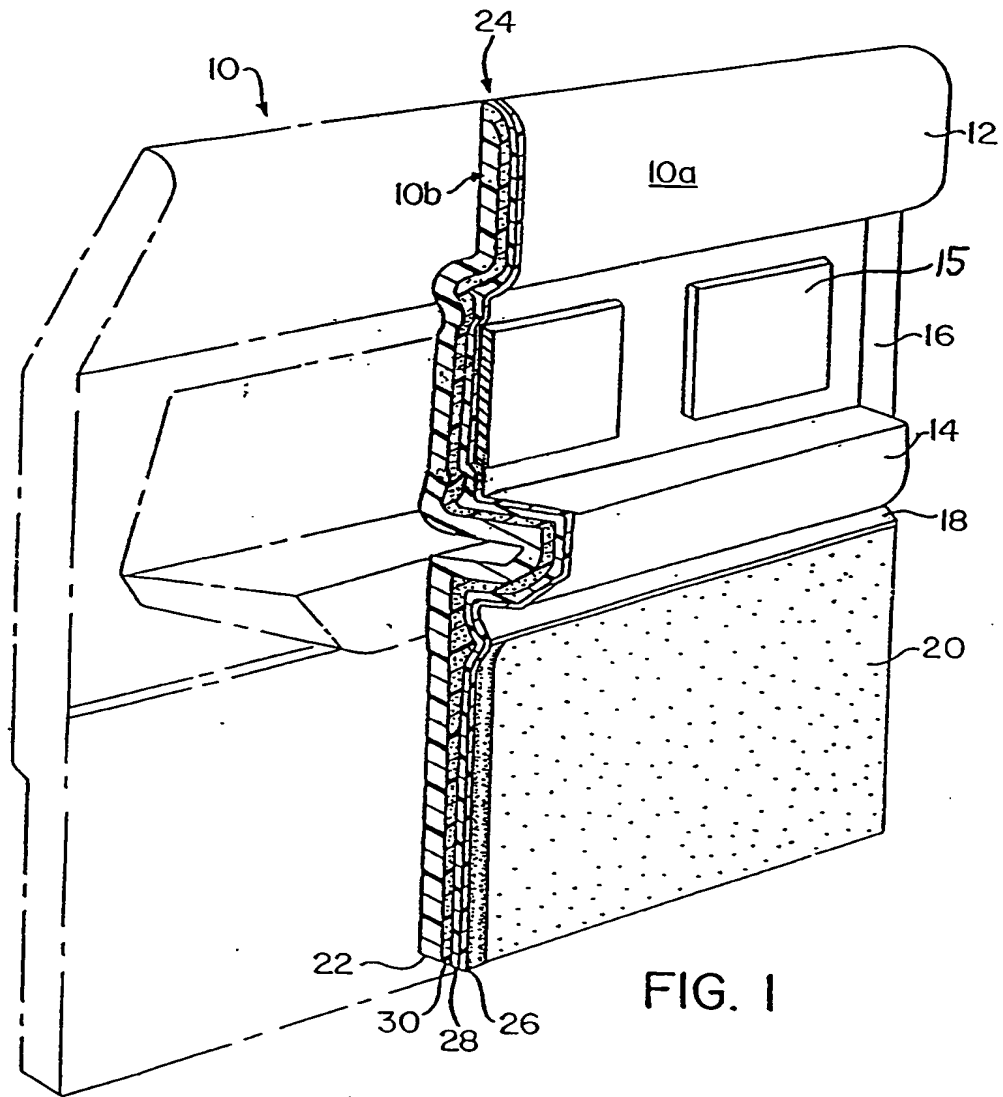


FIG. 1

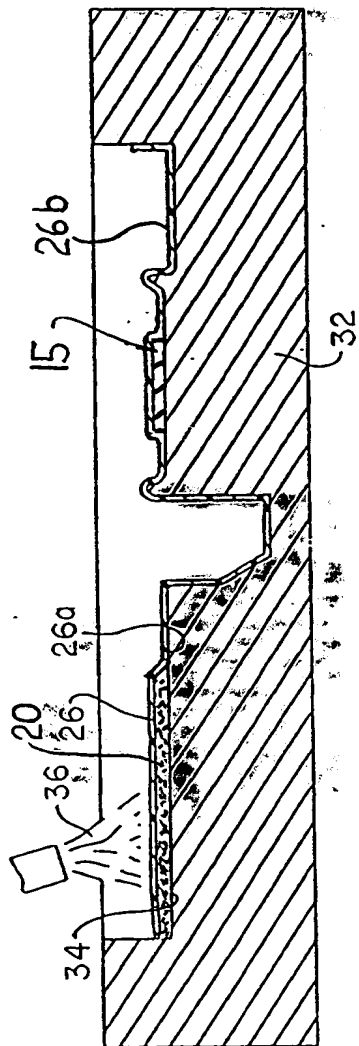


FIG.2

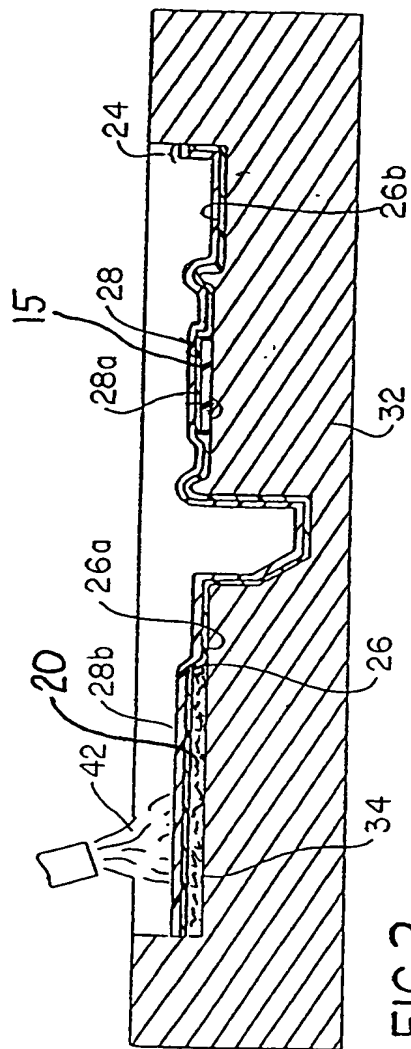
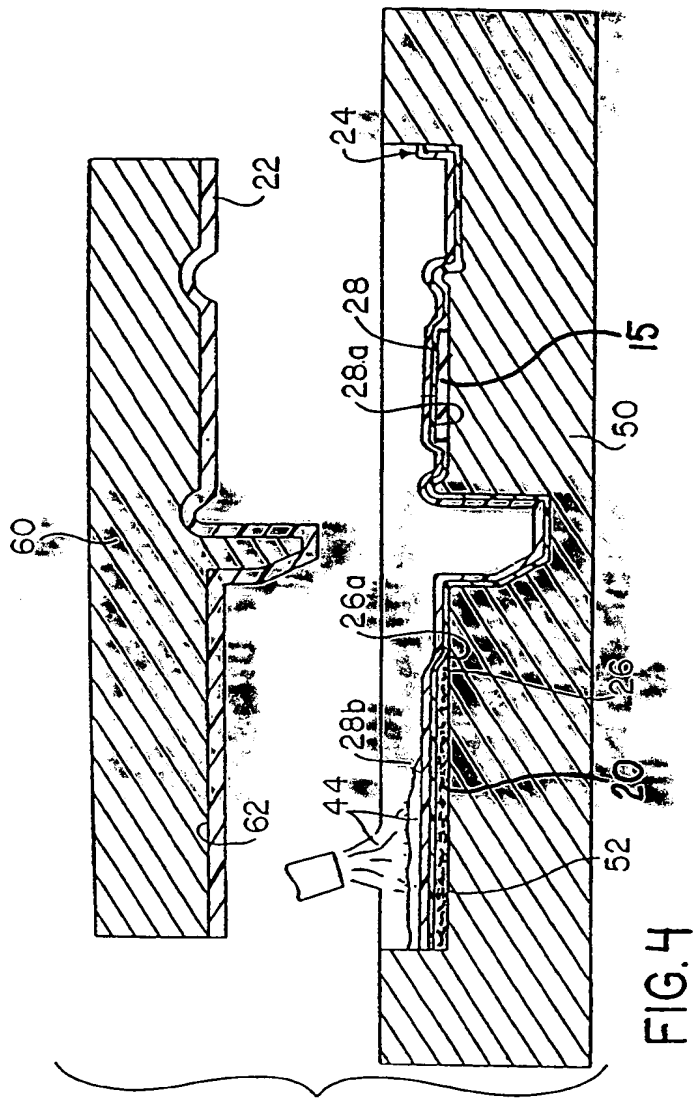


FIG.3



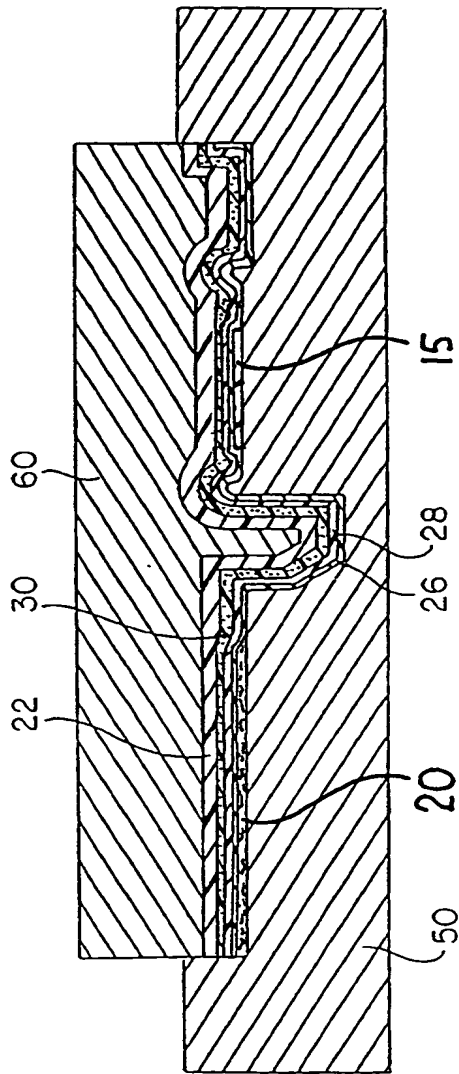


FIG. 5

